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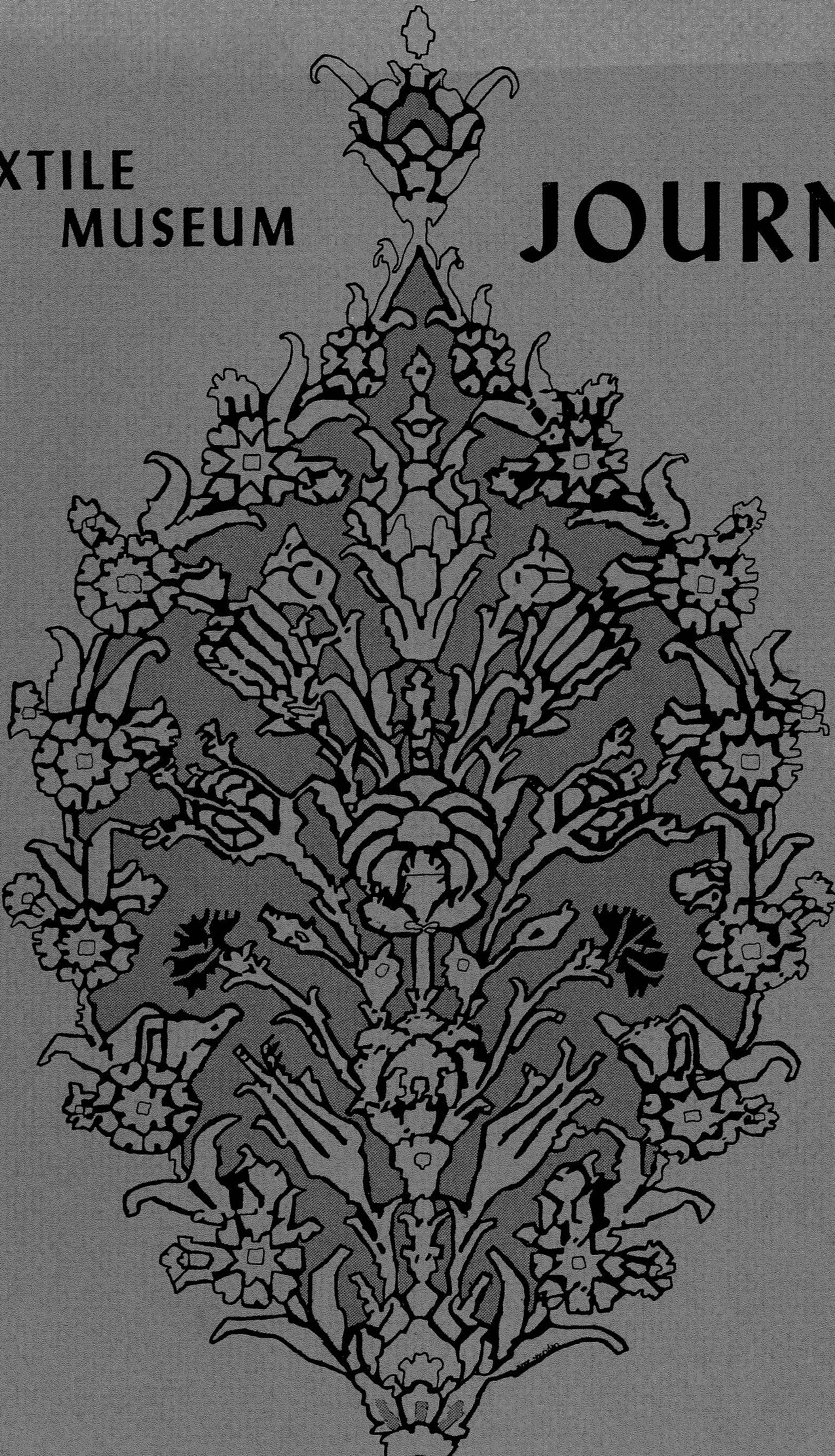

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COVER: Drawing by Anne Sheridan of the large floral oval wreath designed in the center of Textile Museum's "Benguiat" Ottoman prayer rug, 1967.24.1 (Figure 13 in Charles Grant Ellis' article "The Ottoman Prayer Rugs").

DRAWINGS for Color-relationship Chart and illustrations for "How to Match Colors when Dyeing Yarns or Fabrics for Textile Conservation Purposes" by Col. James W. Rice are by Dianne Sisko.
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HOW TO MATCH COLORS WHEN DYEING YARNS OR FABRICS FOR TEXTILE CONSERVATION PURPOSES

JAMES W. RICE

In the previous article, "A Practical Dyeing Method for the Fabric Conservator", Commander Theodore R. Cooley has offered instructive and valuable advice on a procedure for dyeing small lots of yarns for mending or replacing missing original threads in textiles. Unfortunately, not enough space was allotted to him for describing systems for producing matching colors. For this reason the following comments are offered in the hope of adding further information to the subject.

There are two ways of finding suitable dyestuffs for matching colors. First, by searching through the many thousands of dyestuff chemicals offered by manufacturers. This entails finding the exact color hue and type of chemical needed. This particular system is not feasible for the occasional small lot dyer such as a textile conservator. The second system consists of mixing the three primary colors, red, yellow, and blue together with black or by dilution to get the hue and value desired. In order to explain the system as developed and used in instruction by the undersigned over the past quarter century, it will be helpful to define some of the terms and language of color used. These were published in the National Institute of Rug Cleaning Bulletins numbers T-115 and T-116, January, 1958. The essential definitions and explanatory drawings are repeated below.

Primary colors are red, yellow, and blue and in our system may be represented in a plane as points on an equilateral triangle within a circle (Figure 1).

Secondary colors, according to our system of estimating dye mixtures, are made by combining any two of the primary colors. Theoretically, equal amounts of red and yellow should give a standard orange. Likewise, equal proportions of yellow and blue should make a standard green, and blue with red a standard violet. An equilateral triangle pointing in the opposite direction to the primary figure is used to locate graphically our secondaries which may be anywhere between the two primaries depending on the proportions of each. The color orientation wheel now becomes a six-pointed star within a circle (Figure 2).

Tertiary colors, according to our method of graphic representation, consist of all three primaries in various proportions and are to be found somewhere in a circle within the outer circle comprising the primary and secondary hues as is illustrated by Figure 3. Theoretically, a neutral gray will result by mixing all three primary colors in equal portions and would be located at the center of the circle or star, as is shown by Figure 4. This particular point can also be reached by mixing, in proper proportions, any two complementary colors which are found directly opposite one another, as illustrated by Figure 2.

An infinite number of *hues* or different colors, considering the radii and the distances out from neutral or center is possible until the most *vivid* or *saturated* point is reached. Hues from the spectrum are considered most vivid.

If an intense or vivid rainbow hue, such as pure red for example, is mixed with a little of the other primaries, it will approach the center line or neutral gray and its chroma becomes weaker or less saturated. These are called *tones*.

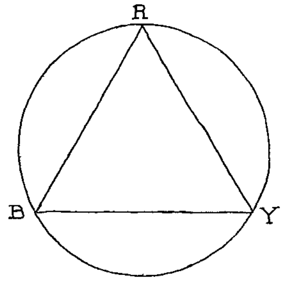

Figure 1

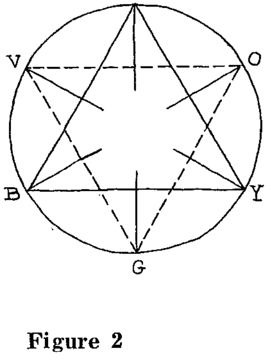

Figure 2

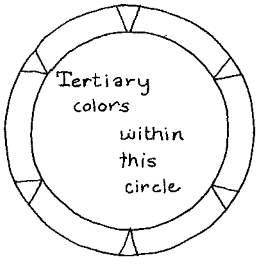

Figure 3

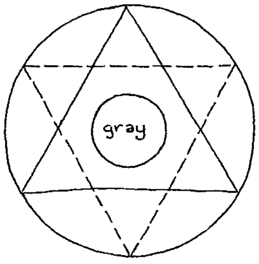

Figure 4

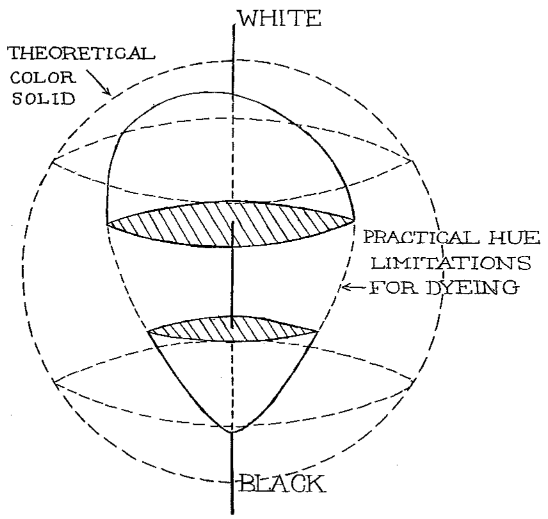

Figure 5 *Sketch of an idealized color solid.*

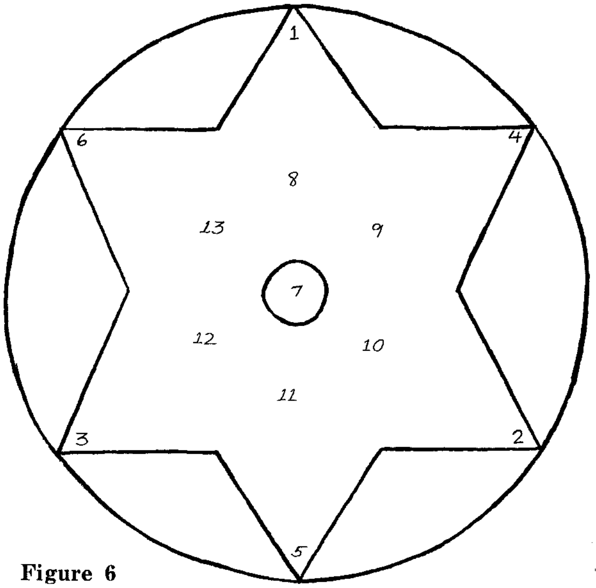

Figure 6

In continuing our graphical illustrations of color terms, it will be necessary to add a third dimension to represent the *neutral* or *achromatic* colors. These range from black to white with neutral gray about midway between. Mixtures of a rainbow hue, such as red with white as in painting, will produce a *tint* such as pink. In dyeing practice, tints are achieved by dilution of the original dye bath.

A *shade* may be considered as a mixture of a rainbow hue and *black.* Some people, however, consider a *shade* as any variation of color. *Dark* connotes a color toward black, whereas *light* implies a change toward white. Shades and tints range in *value* from pure black at zero to the purest white as is represented by magnesium oxide at 100 according to a Reflectometer scale.

In speaking of dyeings, a grayed color may be either a weaker *chroma* or a lowered *value.*

The sketch of an idealized color solid (Figure 5) illustrates the several definitions mentioned above. Actually, this sphere does not truly represent the experimentally produced three parameter color figure. If data are plotted carefully, this imaginary solid would look more like a lopsided egg because of the darkening influence of red and blue over yellow.

How to Make a Dye Color Chart Based on the Three Primary Colors

A dye color chart is a visual aid for estimating the quantities and proportions of standard primary colored dyestuffs necessary to produce any given hue. Anyone who expects to match colors and yarns in a textile conservation problem should construct at least one each for wool and cotton yarns. If much of this work is to be done, four more or two each, representing shade and tint values of the various mixtures are recommended.

To make a color chart one should select dyestuffs in primary colors of the most vivid chroma possible. Each dyestuff chosen should be compatible with those of the other colors in their affinity for the fibers, the assists and the setting agents required and the temperature ranges at which they deposit best on the yarns. Once these dyestuffs are chosen, one should not change them because if he does, he will have to make up a new set of charts.

The color chart as recommended consists of thirteen hues formed of the several colors in the proportions as listed in Table I. The figures given are in parts of one percent stock dye solution in 240 parts of dye bath (48 total parts of dye stock, plus 192 parts of water).

If 12 parts by weight of yarn are dyed to exhaustion (when the solution is almost colorless) the dye acceptance on the basis of yarn weight will be 4% or about the maximum color chroma strength expected.

TABLE I

Star Point Number	Parts Red	Parts Yellow	Parts Blue	Approximate Color
1	48	—	—	Bright red
2	—	48	—	Bright yellow
3	—	—	48	Bright blue
4	24	24	—	Orange (slightly red)
5	—	24	24	Bright green
6	24	—	24	Violet (slightly blue)
7	16	16	16	Natural gray (hard to obtain pure)
8	32	8	8	Mahogany red or grayed red
9	20	20	8	Brown
10	8	32	8	Tan or khaki
11	8	20	20	Dull green
12	8	8	32	Navy blue
13	20	8	20	Purple or dull violet

Figure 6 represents a finished color chart to be used as a key to the various dye proportions in Table I. At least one standard color chart should be made by attaching a sample of each of the individual hues to its assigned position on the chart.

For color charts of lighter tints or values, one may obtain a 2% dyeing by cutting the total dye mixture charge for each hue to 24 parts or a 1% dyeing to 12 parts, keeping the dye liquor and yarn weight proportions at 240 parts and 12 parts of yarn in all cases.

For color charts of darker shades or lower values, black dyes may be added. In this case about 8 parts of black added to the 48 parts of standard primary color dyes should gray down any of these hues markedly.

When dyeing yarns for a color chart, it is desirable to note the behavior of each of the three primary dyes as to: 1) How completely do they exhaust from the dyebath? 2) Does the addition of more leveling agent or assist help the exhaustion? 3) Is exhaustion helped by lowering the temperature? 4) What is the effect of time?

As for use of assist or leveling agents, it has been this writer's experience that acetic acid in dyeing wool yarns should be added sparingly early in the process and increased a little at a time later. In dyeing cotton yarns, the addition of salt is delayed until the dyeing is almost complete. Also, it should be kept in mind that some dyestuffs will not deposit at boiling temperatures but will do so at a lower temperature. Some dyestuffs are absorbed rapidly, whereas others react slowly. Careful observations when the secondary and neutral gray samples are being dyed should be made and recorded in notes as to exhaustion and trueness of shade and chroma.

A simple device for testing a dye solution for color strength and exhaustion is made as follows: Select four test tubes of the same size. Obtain a thin wooden board or a piece of heavy card board about 2½″ wide and 10″ long. Bore four holes, two 2″ apart in the board to receive the test tubes. Place a quantity of clear water in one tube in an outside hole. In the other outside hole place an equal height of the original dye bath solution.

From time to time as the dyeing proceeds put an equal height of the dye bath solution into the third test tube. This is placed in one of the center holes for ease in comparison. If the dyebath shows noticeable color, retain this sample for comparison with the next sample later which is placed in the fourth test tube. In viewing these test samples, one should look down through the tubes towards white paper.

If any of the primary dyes fail to exhaust satisfactorily after adding small quantities of the leveling agents or assists and the dye bath has been kept at a simmer for one-half hour, heating should be discontinued and the solution allowed to cool. During cooling, one should continue to stir the yarn gently and examine a sample of the dye solution every temperature drop of ten degrees F. down to about 160° F. At this point the dyed yarn should be removed, drained, rinsed about five times and dried. In case color is noted in the remaining solution, it should be retained and a new twelve unit skein of yarn entered. This should be reheated to a simmer and the process repeated to try to determine the exhaustion point of the three primary colors and whether or not a 4% dyeing estimate is too high for the particular dyestuff. If exhaustion is not attained in the first place, one should select either a 2% or 1% dye charge for his standard color wheel and for the dosages to arrive at the various colors.

When satisfactory dyeings in all thirteen cases have been achieved, portions of the dyed yarn should be attached to a permanent card in the corresponding positions shown in Figure 6. The remaining yarns may be filed in marked envelopes for wet comparisons in judging future dyeings.

How to Use the Color Chart

Let us suppose that we need a supporting fabric for a textile fragment to be mounted on for display. Perhaps this fragment contains various colors of tan, yellow, red, with a few figures in black. The predominant red is dull. The fragment has several snags and holes in it. Our best guess as to a pleasing color for the background is a color as near the predominant red as possible. The problem now is to determine how to obtain a satisfactory match in chroma and value.

This may be done by comparing the color charts with the red of the fragment by visual study.

Let us now suppose that we judge that our unknown color X will be found somewhere between colors numbers 8 and 13 and we may think of it in descriptive terms as a grayed red-violet or crimson. This we call point X. With this in mind and our color chart, we may now try to shop for suitable materials in some fabric supply shop which may not be possible to find, so we may have to dye material to match.

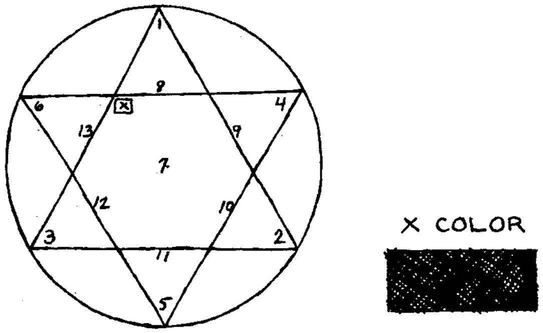

Figure 7

The second step then is to estimate how much of each standard primary color we have at point X. Mark this on a star diagram as shown in Figure 7.

As the third step, make a tabulation form such as is shown in Table II.

TABLE II

	Red	Yellow	Blue
Point A			
Point B			
Difference			
Fraction			
Product			
Point X			

1) Look for the nearest two colors of the 13 shown on the color chart Figure 7.

2) Write down in a similar tabulation form (see Table III) points A and B, in this case points 1 and 13, and enter the proportions of color obtained from Table I in the proper spaces.

3) Subtract the figures in the Red column, entering the difference below in space marked Difference. Do the same for columns Yellow and Blue. See Table III for examples.

4) Estimate whether the unknown color X is ½, ⅓ or ¼ the distance between A and B. (In this case it is about ½.) Enter this in the Table.

5) Multiply each difference by the fraction below it. Enter each production in the proper space.

6) Add or subtract each product to or from the figure opposite Point A or (1) in this case point (13), and enter it as Point X. This now becomes your estimate of the three primary colors or balanced dyes needed for your dye mixture.

TABLE III

	Red	Yellow	Blue
Point A (1)	48	0	0
Point B (13)	20	8	20
Difference	28	8	20
Fraction	−½	+½	+½
Product	−14	−4	+10
Point X	34	4	10

Staff member Miss Karen Jing (center) *explaining procedures for wrapping fragile fabrics for storage.*